# SELECT ASPECTS OF THE LIFE HISTORY AND ECOLOGY OF THE MONTANA ARCTIC GRAYLING (*Thymallus arcticus montanus*) [MILNER] IN THE UPPER BIG HOLE RIVER DRAINAGE, MONTANA

## JUNE 15 TO AUGUST 31, 1990

Final Report - November 1990



*by*

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CONTENTS


List of Figures .......................................... ii

List of Tables .......................................... iii

Acknowledgements .......................................... iv

Summary .......................................... 1

Introduction .......................................... 3

Study Area .......................................... 5

Methods .......................................... 8

Placement of Fry Traps .......................................... 8

Electrofishing .......................................... 8

Stomach Content Analysis .......................................... 9

Core Sampling .......................................... 11

Physical Measurements .......................................... 12

Results And Discussion .......................................... 13

Growth Of Young-Of-The-Year Fishes .......................................... 13

Stomach Content Analysis .......................................... 16

Substrate Composition Of Spawning Sites .......................................... 21

Use Of Irrigation Ditches .......................................... 24

Relative Abundance .......................................... 26

YOY Movement .......................................... 28

Conclusions .......................................... 30

Literature Cited .......................................... 31

## LIST OF FIGURES


| NUMBER | | PAGE |
|---|---|---|
| 1 | Map showing the sample sections and spawning sites in the upper Big Hole River drainage, June to August, 1990. | 6 |
| 2 | Mean total length of three fish species in the Big Hole River, June 15 to August 20, 1990. | 15 |

## LIST OF TABLES


| NUMBER | | PAGE |
|---|---|---|
| 1 | Sampling dates and physical characteristics of upper Big Hole River drainage sampling sections. | 7 |
| 2 | Substrate particle size classes and ranges (modified from the Wentworth classification in Welch, 1948). | 12 |
| 3 | Mean and range of total length of YOY Arctic grayling, brook trout, and mountain whitefish in the upper Big Hole River drainage, June 15 to August 30, 1990. | 14 |
| 4 | Stomach contents analysis sample composition for the Big Hole River and its tributaries, June 19 to August, 30, 1990. | 16 |
| 5 | The Index of Relative Importance (IRI) and its components for the 10 most important food items in the stomachs of brook trout in the Big Hole River, June 18 to August 25, 1990. | 18 |
| 6 | The Index of Relative Importance (IRI) and its components for the 10 most important food items in the stomachs of rainbow trout in the Big Hole River, June 18 to August 35, 1990. | 19 |
| 7 | The Index of Relative Importance (IRI) and its components for the 10 most important food items in the stomachs of burbot in the Big Hole River, June 18 to August 25, 1990. | 20 |
| 8 | Gastric levage efficiency (by volume) and efficiency sample size for brook trout, rainbow trout, and burbot in the Big Hole River, June 18 to August 25, 1990. | 21 |
| 9 | Mean percentage composition for the substrate at each of the six surveyed Big Hole River spawning sites. | 22 |
| 10 | Coefficients of Determination ($R^2$) for substrate composition variables and YOY numbers in the Big Hole River, June to August, 1990. | 24 |
| 11 | Total number of Arctic grayling, brook trout, and mountain whitefish captured by electrofishing (and netting) in the Big Hole River, June 15 to August 30, 1990. | 27 |

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## SUMMARY

This report focusses on several aspects of the Arctic grayling (Thymallus arcticus) population inhabiting the upper Big Hole River drainage in southwestern Montana. The four main aspects include: predation on young of year (YOY) grayling by introduced brook trout (Salvelinus fontinalis), analysis of the substrate composition of six known Arctic grayling spawning sites, use of irrigation ditches in the Wisdom, Montana area by grayling (YOY in particular), and distribution of Arctic grayling in the drainage. Other aspects noted in the report include: movement of YOY grayling in the stretch of river below the Wisdom cemetery; relative abundance of YOY this summer; and growth of YOY grayling.

Two types of fry traps (drift and emergence) were placed at the spawning sites in order to provide general data on time of emergence and number of emerging grayling fry. Unfortunately, no fry were captured by any of the traps.

Arctic grayling YOY had a mean total length of 26.50 mm on June 18, 1990. This rapidly increased to 97.89 mm by the middle of August. YOY mountain whitefish and brook trout had greater mean total lengths than YOY grayling until the end of July when grayling surpassed both other species.

Stomach samples were obtained through gastric levage from brook trout (177), burbot (15), and rainbow trout (5) to determine whether piscivory of YOY grayling was acting as a limiting factor in this system. An Index of Relative Importance (IRI) (George and Haley, 1979) was calculated from the stomach contents data for each of the above three species. The IRIs calculated from the stomach contents indicated that while grayling were not an important food item to any of the three species sampled, fish in general were quite important. This allows for the possibility of predation- induced effects on YOY grayling populations. However, only one YOY grayling was found in any of the stomach samples, so the potential effect is likely small.

The substrates of the six spawning sites are composed primarily of sand (14% ± 4.2) and gravel (81.5% ± 3.2). There was little correlation between YOY numbers at the spawning sites and the site's substrate composition.

Two of the three irrigation ditches sampled showed no use by either YOY or adult grayling. The large ditch on Cal Erb's Ranch near Wisdom, did, however, have some use by both adult and YOY grayling. The ditch also supported some larger brook trout. The only incidence of predation by brook trout on YOY grayling was observed in stomach contents of fish captured from this ditch.

High numbers of YOY grayling were noted in several spots. Swamp Creek, Erb's Ditch, and a double channel below Wisdom (near the mouth of Pintlar Creek) all contained numerous YOY. Adult grayling were most numerous in Swamp Creek and in the east 013

channel of the Big Hole River below Wisdom. The large concentrations of YOY grayling found in the east channel last year (McMichael, 1989) were not observed this year.

Of the 40 grayling tagged this summer, only one was recaptured. This fish was recaptured within 100 meters of the original capture area. Observations suggest that grayling YOY moved out of the spawning areas in mid August and moved downriver.

# INTRODUCTION

The Arctic grayling population of the upper Big Hole River and its tributaries is probably the last riverine population of this species in the lower 48 United States (a small remnant population possibly inhabits the upper Madison River, Montana). Reasons for the current decline of Big Hole River grayling have not yet been adequately determined. Liknes (1981) proposed overharvest, dewatering, and competition with brook trout (*Salvelinus fontinalis*) as probable factors contributing to the decline. Severe drought conditions during the summers of 1988 and 1989 undoubtedly contributed to the decline as well. In September of 1989, a linear density of 338 grayling (YOY and adult) per mile occurred in the river (R. Oswald, pers. comm.).

In 1988, the Montana Natural Heritage Program, the Montana Department of Fish, Wildlife and Parks, the Bureau of Land Management, the U.S. Forest Service, and the Montana Cooperative Fisheries Research Unit initiated a study of the habitat requirements and habits of the Arctic grayling in the upper Big Hole River near Wisdom, Montana. Research has emphasized distribution and habitat use of YOY grayling (Skaar 1988) and interspecific competition for food between Arctic grayling and introduced brook trout (McMichael 1989). Specific objectives of this summer's research included:

1) determine whether predation on YOY grayling by piscivorous fishes is a limiting factor in the Big Hole River system;

2) identify and determine the amount of use of local (Wisdom area) irrigation ditches by grayling;

3) sample and analyze the substrate composition of six identified grayling spawning sites;

4) continue to document the distribution of grayling (YOY and adult) in the Big Hole River drainage.

## STUDY AREA

The upper Big Hole River is characterized by numerous tributary streams and braided channels. Common fish species include Arctic grayling (*Thymallus arcticus*), brook trout (*Salvelinus fontinalis*), burbot (*Lota lota*), white sucker (*Catostomus commersoni*), longnose sucker (*C. catostomus*), mottled sculpin (*Cottus bairdi*), and longnose dace (*Rhinichthys cataractae*). Rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) are less common in the upper portion of the drainage than in the lower sections of the drainage (R. Oswald, pers. comm.).

Six grayling spawning sites (Figure 1) were identified by MDFWP personnel during the spring spawning survey in 1990. The presence of "bright" areas of substrate where the gravel had been washed clean (Shepard and Oswald 1989) was often indicative of a spawning site. Additional sites (Swamp Creek, Pintlar Creek, etc.) were surveyed (electrofished) on the advice of R. Oswald (MDFWP) or because of observations made during the survey.

Three irrigation ditches in the Wisdom area were also surveyed. All three had been sampled at some time during the previous two summers (Skaar 1988; McMichael 1989). Sampling locations, distances, and dates are given in Table 1.

Figure 1. Map showing the sampling sections and spawning sites in the upper Big Hole River drainage, June - August, 1990 (arrows show direction of flow).

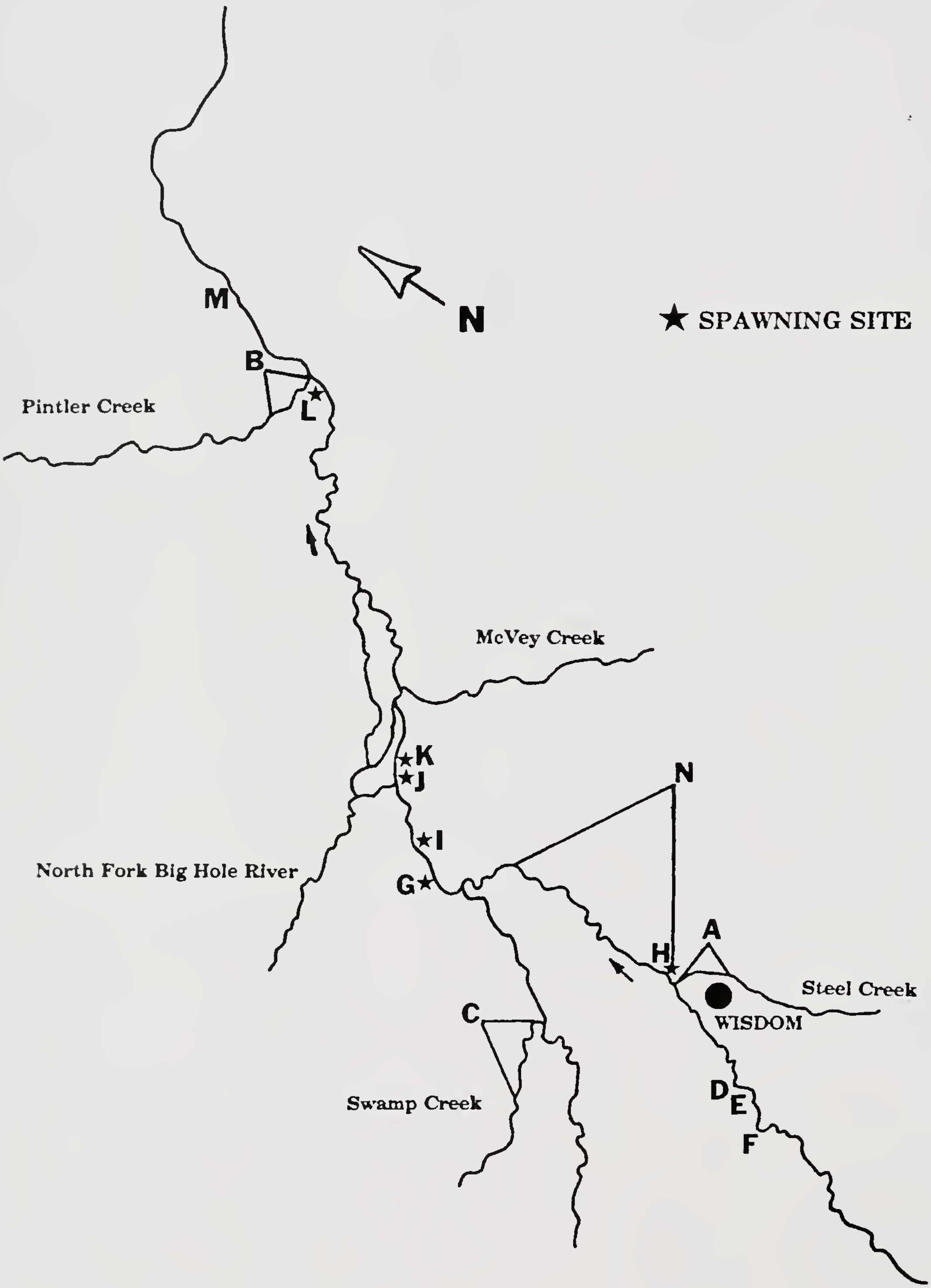


Table 1. Sampling dates and physical characteristics of Upper Big Hole River drainage sampling sections.

| Stream/Sample Section | Length (miles) | Flow ($m^3/s$) | Sampling Dates |
|---|---|---|---|
| **Steel Creek:** | | | |
| A: | 0.5 | 0.15 | 7/17, 24 |
| **Pintlar Creek:** | | | |
| B: | 0.3 | 0.01 | 8/20 |
| **Swamp Creek:** | | | |
| C: Big Hole River to Lower North Fork Road | ~3.0 | 0.10 | 7/24, 26<br>8/22, 23 |
| **Irrigation Ditches:** | | | |
| D: Erb's large ditch | 0.5 | ~0.26 | 7/11, 16, 25 |
| E: Erb's small ditch | 0.2 | ~0.05 | 7/25 |
| F: behind Wisdom Airport | 0.1 | ~0.01 | 8/23 |
| **Big Hole River:** | | | |
| G: Hirshey's pasture* | 0.3 | 1.76 | 7/11 |
| H: near Steel Creek mouth* | 0.1 | 0.46 | 7/18, 8/20 |
| I: below gravel pit* | 0.1 | 1.02 | 7/17 |
| J: Buffalo Ranch 1* | 0.2 | 0.76 | 7/12, 8/17 |
| K: Buffalo Ranch 2* | 0.2 | 0.95 | 8/23 |
| L: Bottoms* (double channel) | ~0.2 | 0.10 | 7/12, 17, 27<br>8/2, 16, 22 |
| M: upstream from Squaw Creek bridge 3.5 miles | ~0.1 | <0.1 (est.) | 7/18 |
| N: below Wisdom | 2.0 | 1.5 (est.) | 7/12 |

* Spawning site

# METHODS

## Placement of Fry Traps

Fry traps of two varieties (drift and emergence) were placed at each of the six identified spawning sites. The emergence traps (Fraley, et al., 1986) were placed on the riffle areas of the spawning sites and held stationary with large rocks.

Drift traps (Wolf 1950) were placed in the thalweg, slightly downstream from the spawning site, to capture fry after they had emerged from the gravel and were moved downstream by the current. The drift traps were anchored to the substrate with steel rebar.

Fry traps were checked one or two times daily depending on weather conditions. Water temperatures were recorded at each site daily with a pocket thermometer.

## Electrofishing

The 14 sampling sites (including the six identified spawning sites) were electrofished with either a Coffelt Model BP-1C backpack electrofishing unit (operated on half-pulsed direct current at 100-200 watts of power) or a boat-mounted bank unit with a 120-watt, gasoline-powered generator and a Harley Leach rectifying unit to convert AC current to half-pulsed direct current. Electrofishing took place in either an upstream or a downstream direction depending on stream conditions and access availability.

Of the fish affected by the electric current, only salmonids and burbot were netted and placed in a holding net. Most captured fish were anaesthetized wit 4-amino benzoate (if needed), identified to species, measured to the nearest mm total length (TL), and released. Some of the captured YOY grayling were weighed to the nearest gram with an Ohaus Lume-o-gram electronic balance for condition factor calculation. The equation

$$K = \frac{(W)\ (100{,}000)}{L^3}$$

W = weight in grams
L = length in mm.

was used for condition factor calculation.

Select brook trout, rainbow trout, and burbot had stomach contents removed through gastric levage before being released.

## Stomach Content Analysis

Gastric levage was performed on brook trout (n=177), rainbow trout (n=5), and burbot (n=15) as described by Light, et al., (1983) to secure stomach contents for later analysis. The contents were flushed into storage bottles using Light's levage device, and preserved in a 5% formalin solution or an ethanol solution. Several fish (n=10) were sacrificed to determine the efficiency of gastric levage in this study. Stomachs were removed and preserved to later identify any remaining contents.

Stomach contents were identified to order and/or family, using a dissecting microscope, and enumerated. Sample volumes were determined by placing the items in a graduated cylinder containing 50 ml of water and noting the displacement caused by the sample.

Since no single analysis (volumetric, numerical, or frequency of occurrence) will provide an accurate analysis of stomach contents, an index of all three was used. The Index of Relative Importance (IRI) (George and Hadley 1979) combines all three of the above types of analyses to provide a much more accurate analysis of the relative importance of the food items in the sample:

$$RI_a = \frac{100\ (fI_a + pI_a + vI_a)}{\sum_a (fI_a + pI_a + vI_a)}$$

where

$fI_a$ = frequency of occurrence
$pI_a$ = percent of total numbers
$vI_a$ = percent by volume

The values in this index ($RI_a$) range from 0 to 100, with 100 indicating exclusive use of a food item (Hensler 1987). Volume was substituted for weight as in Hensler (1987).

Frequency of occurrence of a given food item ($fI_a$) was obtained by dividing the number of sample stomachs (by species) that contained at lease one of that food item by the total number

of stomachs for that species in the sample (Bowen 1983). The percent by volume of each item ($vI_a$) was calculated by dividing the total volume of each food type by the combined volume of all food types. Where food items were too small to obtain individual volumes accurately, the total volume of these items was divided by the number of items in the sample. Volumes for each category of food item were then summed and divided by the total volume to obtain the percentage volume of that category in the sample. The percent total numbers ($pI_a$) is the number of food items in a given type expressed as a percentage of the total number of food items of all types in the sample (Bowen 1983).

## Core Sampling

Core samples were removed from each of the six spawning areas for substrate composition analysis. Ten core samples were taken from each site with a standard six-inch corer. The samples were taken randomly from the rifle only, on a transect across the riffle and perpendicular to the flow, if the riffle was well defined and large enough. Otherwise, the ten samples were taken along a transect intersecting the entire stream at the spawning area and perpendicular to the stream flow. Samples were taken at even intervals, or approximately every one-tenth of the riffle or stream width.

After removing the sample from the corer, depth inside the core and outside the core (stream depth at that position) were measured using a meter stick. Water in the corer was then

agitated by hand and a 1.0-liter Imhoff cone sample of water was obtained from inside the corer. After the cone sample settled for twenty minutes, the settled suspended material was read in mg/l.

Core samples were stored in plastic bags, labeled and transported to the U.S. Forest Service Helena Ranger District lab, where they were sieved and weighed. The sieve series consisted of 50.8, 25.4, 12.4, 9.5, 6.3, 2.36, 0.85, and 0.074 mm sieves. (Table 2).

Table 2. Substrate particle size classes and ranges (Modified from the Wentworth classification in Welch 1948).

| Substrate class | Particle size range (mm) |
|---|---|
| Cobble | >50.8 |
| Gravel | 0.85 - 50.8 |
| Fines | |
| Sand | 0.074 - 0.85 |
| Silt | <0.074 |

## Physical Measurements

Current velocities were measured with a Teledyne Gurley Model 622 current meter at 60% of the depth. Discharges (in cubic meters per second) were calculated according to the methods of Armour and Platts (1983).

## RESULTS AND DISCUSSION

### Growth of Young-of-the-Year Fishes

Arctic grayling YOY averaged 26.5 mm in total length (n=13) on June 18 (Table 3, Figure 2). Their length rapidly increased to 97.9 mm by mid to late August. These lengths are similar to those found by both Skaar (1988) and McMichael (1989) during the previous years of this study, and considerably higher than the lengths found by Liknes (1981). YOY grayling found by Liknes (1981) had a mean total length of 55.2 mm (n=44) during July 11-15, while YOY captured in this study during roughly the same time period had a mean total length of 64.8 mm. Size variations may be caused by differing growth rates at different sampling sites, older age of YOY caused by earlier spawning and/or emergence of fry, or as McMichael (1989) proposed, differences in water temperatures.

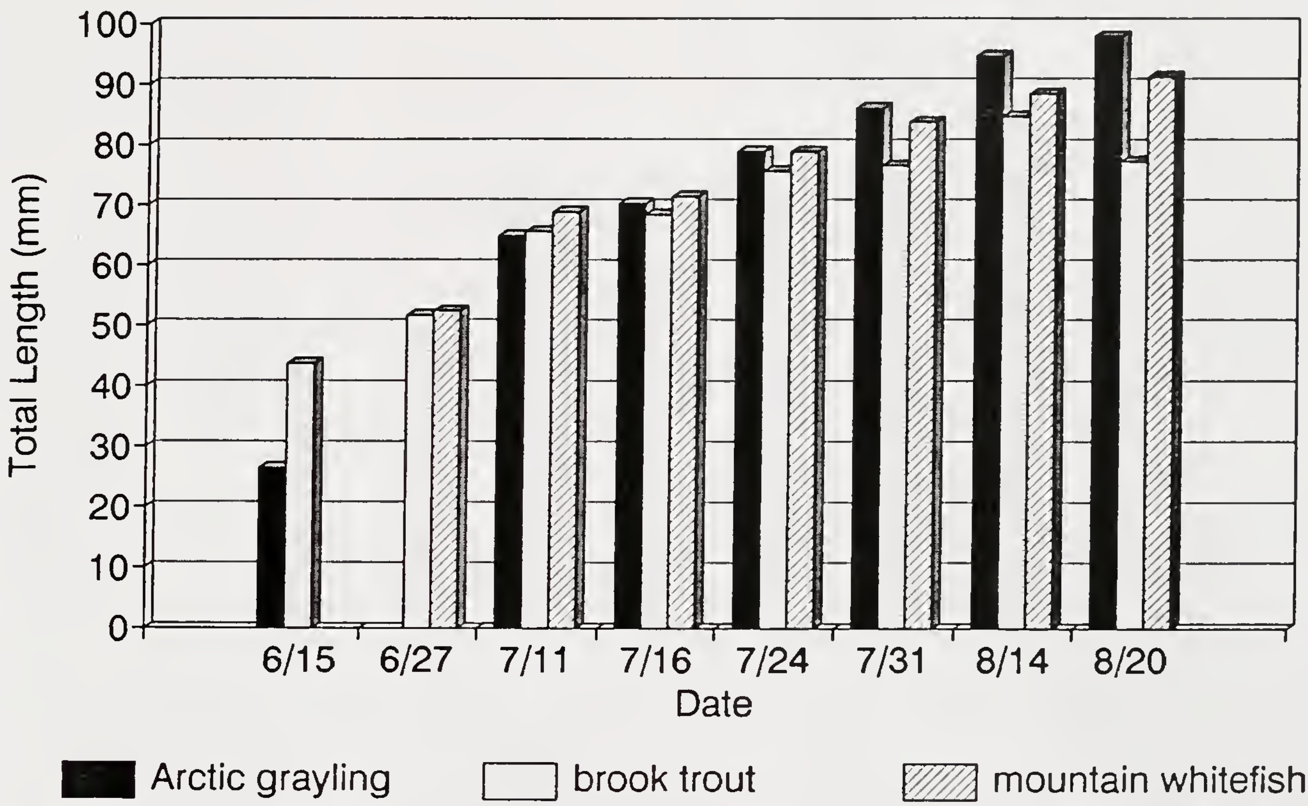
Young-of-the-year mountain whitefish and brook trout had greater mean total lengths than grayling until the end of July, when grayling YOY surpassed them in mean total length (Table 3, Figure 2). This indicates a rapid growth rate for the spring-spawned grayling. Both McMichael (1989) and Skaar (1988) reported lengths for brook trout and mountain whitefish in this area during the past two summers similar to those reported here.

Condition factors (K) were calculated for 31 YOY Arctic grayling captured between August 14 and 22 of this year. The mean K for this sample was 0.92. This condition factor was

Table 3. Mean and range of total length of YOY Arctic grayling, brook trout, and mountain whitefish in the Big Hole River drainage, June 15 to August 31, 1990.

| | Arctic Grayling | | | Brook Trout | | | Mountain Whitefish | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Mean (SD) | Range (mm) | N | Mean (SD) | Range (mm) | N | Mean (SD) | Range (mm) | N |
| 6/15-18 | 26.50 (4.5) | 20-32 | 13 | 43.50 (2.1) | 42-45 | 2 | ---- | ---- | -- |
| 6/27 | ---- | ---- | --- | 51.40 (7.1) | 41-59 | 5 | 52.30 (2.1) | 50-54 | 3 |
| 7/11-12 | 64.80 (2.9) | 60-68 | 5 | 65.40 (12.4) | 51-81 | 5 | 68.70 (5.2) | 61-75 | 10 |
| 7/16-17 | 70.20 (2.9) | 63-75 | 29 | 68.20 (12.7) | 36-85 | 27 | 71.30 (5.3) | 63-81 | 27 |
| 7/24-26 | 78.64 (5.4) | 68-92 | 25 | 75.52 (8.4) | 54-97 | 109 | 78.70 (6.5) | 72-91 | 10 |
| 7/31-8/2 | 85.86 (5.0) | 74-99 | 72 | 76.26 (12.2) | 41-97 | 23 | 83.50 (4.9) | 66-91 | 149 |
| 8/14-16 | 94.50 (6.8) | 79-107 | 26 | 84.60 (10.8) | 56-109 | 179 | 88.22 (11.1) | 76-102 | 27 |
| 8/20-23 | 97.89 (10.8) | 74-109 | 9 | 77.16 (9.6) | 54-97 | 45 | 91.00 (5.9) | 82-99 | 9 |

Figure 1. Mean total length of three fish species in the Big Hole River, June 15 - August 20, 1990.



similar to that found by Liknes (1981) where K ranged from 0.90 to 0.97 for adult Arctic grayling. Most of the YOY captured over the summer appeared to be in very good condition. The higher discharges and cooler water temperatures prevalent over much of the study area in 1990 may explain the good condition of the YOY.

## Stomach Contents Analysis

At various sites and on various sampling dates (Table 4), stomach contents were collected from 177 brook trout, 5 rainbow trout, and 15 burbot. Numbers, species, dates, and locations of fish sampled are shown in Table 4.

Table 4. Sample composition for analysis of stomach contents of fish from the Big Hole River and its tributaries, June 19 to August 23, 1990.

| Sampling sites | Sampling dates | Species | Number sampled |
|---|---|---|---|
| Below Wisdom (East and West Channels) | 6/19,20,28,29<br>7/12,31 | Brook Trout<br>Burbot<br>Rainbow Trout | 129<br>10<br>3 |
| Erb's Ditch #1 | 7/16,25 | Brook Trout<br>Burbot<br>Rainbow Trout | 14<br>1<br>1 |
| Hershey's Pasture | 7/11 | Brook Trout<br>Burbot | 3<br>1 |
| Bottom Section | 7/12 | Brook Trout | 2 |
| Swamp Creek | 8/14,22,23 | Brook Trout<br>Burbot | 28<br>2 |
| Buffalo Ranch 1 | 8/12 | Brook Trout<br>Burbot | 1<br>1 |
| Deep Creek | 8/21 | Rainbow Trout | 1 |

Of the 92 fish found in brook trout stomachs, 31 (34%) were identified to species. Indices of Relative Importance and their components for brook trout, rainbow trout, and burbot are located in Tables 5, 6, and 7, respectively. Fish rank second or third in relative importance in the diets of all three sample species. Only one Arctic grayling YOY was positively identified in the 197 samples. The YOY grayling was found in the stomach of a 275 mm brook trout captured in the large irrigation ditch on Cal Erb's ranch (formerly the McDowell Ranch) near Wisdom.

Another possible predator on YOY is the brown trout, a well documented piscivore (Brown 1971). Although found infrequently in the upper portions of the Big Hole drainage, the brown trout is quite common in the lower reaches of the Big Hole River (R. Oswald, pers. comm.) If YOY Arctic grayling migrate downstream in the fall, they may be preyed upon by brown trout. Such predation by brown trout on YOY could be substantial and may play a part in the large drop in YOY populations observed during their first winter. Further study is necessary to address this issue.

The results from the stomach content analyses indicate that YOY Arctic grayling are not an important component in the diets of the three species sampled. These results do not necessarily indicate that predation on YOY grayling is not acting as a limiting factor on YOY populations. Further sampling of stomach contents, as well as a determination of YOY grayling availability to possible predators are needed to determine whether or not predation is really acting as a limiting factor.

Table 5. The Index of Relative Importance (IRI) and its components for the 10 most important food items in the stomachs of brook trout in the Big Hole River, Montana, June 18 to August 25, 1990.

| Food Item | Freq. of Occurrence | Volume | Number | IRI |
|---|---|---|---|---|
| Ephemeroptera | 0.5650 | 0.2275 | 0.7873 | 28.08 |
| Fish (total*) | 0.3330 | 0.4171 | 0.0204 | 13.70 |
| Terrestrial ** | 0.5198 | 0.0998 | 0.0477 | 11.86 |
| Fish (unidentified) | 0.2316 | 0.1864 | 0.0137 | 7.67 |
| Trichoptera | 0.3107 | 0.0687 | 0.0243 | 7.18 |
| Corixidae | 0.2260 | 0.0208 | 0.0263 | 4.85 |
| Longnose dace | 0.0734 | 0.1774 | 0.0059 | 4.56 |
| Dytiscidae | 0.1638 | 0.0402 | 0.0308 | 4.17 |
| Tipulidae | 0.1412 | 0.0475 | 0.0111 | 3.55 |
| Plecoptera | 0.1525 | 0.0152 | 0.0208 | 3.35 |

* Total includes identified and unidentified fishes.
** Terrestrial includes Hymenoptera, Diptera (non-aquatic), Arachnida, and Homoptera.

Table 6. The Index of Relative Importance (IRI) and its components for the 10 most important food items in the stomachs of rainbow trout in the Big Hole River, Montana, June 18 to August 25, 1990.

| Food Item | Freq. of Occurrence | Volume | Number | IRI |
|---|---|---|---|---|
| Ephemeroptera | 0.80 | 0.2955 | 0.4857 | 21.99 |
| Fish (total*) | 0.40 | 0.3636 | 0.1524 | 12.74 |
| Trichoptera | 0.60 | 0.0636 | 0.1333 | 11.08 |
| Plecoptera | 0.60 | 0.0818 | 0.0952 | 10.81 |
| Fish (unidentified) | 0.20 | 0.2424 | 0.1429 | 8.14 |
| Tipulidae | 0.40 | 0.0697 | 0.0381 | 7.06 |
| Culicidae | 0.40 | 0.0167 | 0.0190 | 6.06 |
| Longnose dace | 0.20 | 0.1212 | 0.0095 | 4.60 |
| Terrestrial** | 0.20 | 0.0697 | 0.0476 | 4.41 |
| Dytiscidae | 0.20 | 0.0061 | 0.0095 | 4.05 |

* Total includes identified and unidentified fishes.
** Terrestrial includes Hymenoptera, Diptera (non-aquatic), Arachnida, and Homoptera.

Table 7. The Index of Relative Importance (IRI) and its components for the 10 most important food items in the stomachs of burbot in the Big Hole River, Montana, June 18 to August 25, 1990.

| Food Item | Freq. of Occurrence | Volume | Number | IRI |
|---|---|---|---|---|
| Ephemeroptera | 0.333 | 0.1786 | 0.4631 | 27.80 |
| Plecoptera | 0.200 | 0.0992 | 0.1477 | 12.75 |
| Fish (unidentified) | 0.133 | 0.1587 | 0.0134 | 8.70 |
| Fish (total*) | 0.133 | 0.1587 | 0.0134 | 8.70 |
| Tipulidae | 0.067 | 0.1706 | 0.0336 | 7.73 |
| Frog | 0.067 | 0.1587 | 0.0067 | 6.62 |
| Trichoptera | 0.133 | 0.0556 | 0.0201 | 5.95 |
| Dysticidae | 0.067 | 0.0794 | 0.0537 | 5.70 |
| Culicidae | 0.067 | 0.0159 | 0.0268 | 3.12 |
| Corixidae | 0.067 | 0.0119 | 0.0201 | 2.82 |

* Total includes identified and unidentified fishes.

The use of gastric levage in this study was an accurate method for securing stomach contents of brook and rainbow trout for analysis (Table 8). The method was slightly less efficient in removing the stomach contents of burbot. Most of the inefficiency, however, occurred early in the sampling season and our efficiency improved as the summer progressed.

Table 8. Gastric levage efficiency (by volume) and efficiency sample size for brook trout, rainbow trout, and burbot in the upper Big Hole River drainage, June 18 to August 23, 1990.

| Species | Efficiency | Sample Size |
|---|---|---|
| Brook trout | 92% | n=5 |
| Rainbow trout | 100% | n=1 |
| Burbot | 83% | n=4 |

## Substrate Composition of Spawning Sites

Mean percentage composition of the substrate at the six spawning sites is shown in Table 9. The substrate is primarily sand and gravel at all of the sites. The greatest amounts of fines (silt and sand particles) occurs at site J (Buffalo Ranch 1). Site J is located at the point where the North Fork of the Big Hole River empties into the main river. On days of average or above average water clarity, large amounts of sand and small-gravel sized sediments were seen moving out of the North Fork and into this spawning site in the main stem.

Table 9. Mean percentage (SD) composition of the substrate at each of the six surveyed Big Hole River spawning sites.

| Spawning Site | % Fines | | % Gravel | % Cobble |
|---|---|---|---|---|
| | Sand | Silt | | |
| G | 13.71 (9.88) | 0.47 (0.32) | 85.29 | 0.53 (1.68) |
| H | 8.04 (3.06) | 0.26 (0.42) | 82.03 | 9.67 (8.68) |
| I | 13.74 (6.47) | 0.25 (0.17) | 80.32 | 5.69 (8.85) |
| J | 21.02 (5.98) | 0.64 (0.75) | 78.34 | 0.00 (0.00) |
| K | 12.58 (3.99) | 0.24 (0.13) | 85.09 | 2.09 (3.78) |
| L | 15.17 (4.87) | 0.32 (0.20) | 78.17 | 6.34 (6.20) |

High percentages of fine particles in the substrate have been shown to have a negative effect on salmonid eggs and fry (Hausle and Coble 1976; Phillips et al. 1975). Hausle and Coble (1976) found that sand inhibited the emergence of brook trout, but emergence was still between 80 and 90% when 20% of the spawning substrate was composed of sand (the highest percentage at any of the Big Hole spawning sites). However, Phillips, et al., (1975) found that mean survival to emergence of coho salmon (Onchorhynchus kisutch) and steelhead (O. mykiss) fry was roughly 70% when sand made up 20% of the substrate. If grayling are similarly affected, the 20% sand in the Big Hole substrate may be lowering fry emergence by 10 to 30%.

However, several studies dealing with grayling (Scott and Crossman 1973; Nelson 1954; and Bishop 1971) have indicated that grayling will spawn over a wide variety of substrates ranging from boulders to sand. Because grayling do not build redds (Scott and Crossman 1973), substrate composition may not be an extremely important variable in determining spawning success.

There appears to be little or no correlation ($R^2$) between substrate composition and the numbers of YOY at or near the spawning sites (Table 10). There is little correlation between YOY grayling numbers and the percentage of gravel in the substrate, where 28% of the variation in YOY grayling numbers is attributed to the percentage of substrate gravel.

There are several possible reasons for these low correlations. First, selection of spawning substrate by grayling

may not be closely related to the particle-size composition of the substrate. Second, the actual numbers of YOY grayling using the site and the numbers we sampled by electrofishing may be completely different (i.e., the electrofishing results do not accurately reflect the numbers present). Third, the sites cored for substrate analysis may not be completely representative of the actual spawning site. Further substrate analysis and an improved and more accurate method of estimating YOY grayling numbers in a given area are needed to more accurately assess the relationships between YOY grayling and substrate composition.

Table 10. Coefficients of determination ($R^2$) for substrate composition variables and YOY numbers in the Big Hole River, Montana, June - August, 1990.

| Variable | Mean % | (SD) | $R^2$ |
|---|---|---|---|
| Sand | 14.04 | (4.203) | 0.0172 |
| Silt | 0.036 | (0.1603) | 0.0201 |
| Gravel | 81.54 | (3.162) | 0.2803 |
| Cobble | 4.053 | (3.799) | 0.0910 |

## Use of Irrigation Ditches

Three irrigation ditches were electrofished: two on Cal Erb's Ranch and one near the Wisdom Airport (Figure 1). The small irrigation ditch (Table 1) near the airport was narrow and weed-choked when sampled, and use by salmonids was minimal. No

Arctic grayling or other trout were captured, although suckers, dace, and sculpins were present in varying numbers. Sampling occurred later in the season (Table 1), so some spring use may have gone unobserved.

The smaller of the two irrigation ditches on Erb's Ranch also had minimal use by fish of any kind. In addition to the ubiquitous suckers and dace, only one brook trout YOY and one mountain whitefish YOY were captured in the ditch. No Arctic grayling (YOY or adult) were found in the ditch.

The larger irrigation ditch on Erb's Ranch has a significant flow throughout the summer (Table 1). Twelve YOY and two adult arctic grayling were captured, as well as several large brook trout and burbot. Numerous YOY grayling were observed in schools in the ditch, but only the twelve were secured. Electrofishing effectiveness may have been limited by low conductivity.

There is a possibility of losing these fish during the fall when the ditch is dewatered. This presents an exceptional opportunity for testing an incremental dewatering of the ditch and the effectiveness of this method in returning grayling to the river. The landowner was very helpful in providing access and may be amenable to testing an incremental shutdown.

## Relative Abundance

In general, this project was not designed to sample the relative abundance of Arctic grayling or brook trout. However, while sampling for brook trout (for the stomach contents analysis), and while sampling the spawning sites and tributaries, several significant concentrations of fish were encountered (Table 11).

Swamp Creek, as noted by Skaar (1988), and to a lesser extent by McMichael (1989), contained significant numbers of YOY (Table 11). The highest concentrations of YOY grayling found by McMichael (1989) were located in the east channel of the Big Hole River below the town of Wisdom (Section N on Figure 1). The higher concentration for this section was not observed during 1990, although higher discharges this year may have lowered the overall effectiveness of our electrofishing gear and methods.

Significant concentrations of YOY grayling were also found this year in Erb's Ditch #1 just upriver from Wisdom and near one of the spawning sites (Bottom Section). Adult (I+) grayling were most numerous in Swamp Creek and in the east channel below Wisdom (Section N).

High concentrations of brook trout were noted in three of the tributary streams in the study area. Pintlar Creek, Swamp Creek, and Steel Creek had high concentrations of brook trout with Swamp Creek having the highest (based on simple counts of brook trout, not on population estimates). Few (less than ten) rainbow trout were sampled during the summer.

Table 11. Total number of Arctic grayling, brook trout and mountain whitefish captured by electrofishing (or netting) in the Big Hole River drainage, June 15 to August 31, 1990.

| Stream/ Sample Section | Number Captured | | | | | |
|---|---|---|---|---|---|---|
| | Arctic grayling | | brook trout | | mountain whitefish | |
| | YOY | I+ | YOY | I+ | YOY | I+ |
| Steel Creek | | | | | | |
| A: | 0 | 2 | 49 | 77 | 16 | 0 |
| Pintlar Creek | | | | | | |
| B: | 1 | 1 | 41 | 33 | 0 | 0 |
| Swamp Creek | | | | | | |
| C: | 33 | 5 | 284 | 143 | 23 | 0 |
| Irrigation Ditches | | | | | | |
| D: | 12 | 2 | 1 | 25 | 10 | 0 |
| E: | 0 | 0 | 1 | 0 | 1 | 0 |
| F: | 0 | 0 | 0 | 0 | 0 | 0 |
| Big Hole River | | | | | | |
| G: | 0 | 0 | 1 | 3 | 1 | 0 |
| H: | 0 | 0 | 10 | 6 | 5 | 1 |
| I: | 3 | 0 | 2 | 5 | 0 | 0 |
| J: | 0 | 0 | 0 | 1 | 2 | 2 |
| K: | 0 | 0 | 1 | 0 | 0 | 4 |
| L: | 118 | 0 | 60 | 19 | 92 | 0 |
| M: | 0 | 0 | 0 | 0 | 0 | 0 |
| N: | 4 | 6 | 6 | 6 | 109 | 9 |

## YOY Movement

McMichael (1989) observed that large concentrations of YOY grayling were often observed near the areas where spawning grayling had been found. This was true in only one of the six spawning sites sampled in the present study. We found large concentrations of YOY in section L (Bottoms) only. Discharges (Table 1) were considerably higher at all other sampled spawning sites. It is possible that the higher discharges this year hampered sampling of YOY by our electrofishing gear. YOY (mean length = 26.5 mm) were first captured near the edges of submerged vegetation.

Few YOY grayling were found in the river below the Wisdom cemetery downstream to Pintlar Creek during the 1990 fall population estimates (R. Oswald, pers. comm.). In order to help determine where the YOY produced in this section move, we marked 40 YOY grayling (29 with an adipose clip and 11 with a notched anal fin) in section L. The section was then electrofished every 7 to 14 days in an attempt to observe any movements.

Of the marked fish, only one was recaptured, three weeks after being marked. This fish was recaptured within 1 to 2 meters of the original capture location, although this is probably the result of "herding" the fish with the electrofishing gear.

During the middle of August, flows in section L dropped to an unmeasurable discharge and the YOY grayling nearly disappeared, with only 3 to 6 grayling captured per visit from

section L. At this point, several YOY grayling were captured in the main stem of the river, downstream from section L. No YOY had previously been captured in this location. Since none of the YOY captured below section L had been marked, it is impossible to conclude that the YOY in section L all went downstream. However, circumstantial evidence would seem to indicate that at least some did move downstream.

## CONCLUSIONS

This study attempted to identify several possible factors that may be limiting the Big Hole River population of Arctic grayling. Based on stomach contents collected in this study, we have found that while brook trout can and will prey upon YOY grayling, the amount of predation actually occurring on YOY is probably not limiting the grayling population. In addition, substrate composition does not appear to be highly correlated with YOY numbers, although several study design problems were discussed. The use of irrigation ditches by grayling appears to be minimal except in one case discussed. If grayling do leave the ditch in the fall, then the adverse impact on them would be negligible and no further steps other than monitoring need be taken. Data collected on the movements of YOY in the river section below the Wisdom cemetery is circumstantial due primarily to the low numbers of YOY marked. The data, however, may indicate that the YOY move downstream.

The proposed stocking of the river with hatchery-reared grayling, and continued studies such as this one, as well as those of McMichael (1989) and Skaar (1988), are vital in not only maintaining and increasing Arctic grayling populations in the Big Hole River drainage, but also in determining the causes for their decline. Until these causes are identified, and corrective measures result in substantial increases in grayling numbers, the grayling population in the Big Hole River should remain of special concern.

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